



UiO : Department of Technology Systems University of Oslo

TEK5530: Before we start - interactivity - participation

Reach out: Josef Noll +47 9083 8066 (ph, SMS, WhatsApp/Threema/Signal/Telegram/Wire....)

Zoom

- have camera on if possible (easier for me to talk to people, not to blank screens)
- say hello from everybody before we start the lecture (5-10 min social talk)
- fixed stops to ask questions

Other forms for feedback

- one/two representatives as mediators to György and me
- Mentimeter feed-back
- chat i Zoom
- common Telegram/WhatsApp/Signal/Threema group



Info on our wiki: <http://its-wiki.no/wiki/TEK5530>



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University of Oslo

TEK5530 - Measurable Security for the Internet of Things

L1 – Introduction

György Kálmán,
UiO
gyorgy.kalman@its.uio.no

Josef Noll
UiO
josef.noll@its.uio.no



<https://its-wiki.no/wiki/TEK5530>

Overview

- Expectations
- Lecture overview
- Exam
- Topic introduction

Expected outcome:

- Describe application-driven security and establish challenges of sensor-driven systems
- Provide industrial examples, e.g. Smart Grid and automatic meter readings
- Establish application-driven security goals as well as the semantics of your system

- Be able to describe the security impact of components and sub-systems
- Perform a multi-metrics analysis to measure the system security
- Analyse application goal versus system security, be able to describe differences and mitigation solutions
- Be able to analyse and present own thoughts on a scientific paper
- Group work with distribution of workload



TEK5530: Lecture plan

- 20.01
 - ⇒ L1: Introduction (Josef Noll)
- 27.01 (Gyorgy Kalman)
 - ⇒ L2: Internet of Things
- 03.02 (Gyorgy Kalman)
 - ⇒ L3: Security of IoT + Paper list
- 10.02 (Josef Noll)
 - ⇒ L4: Smart Grid, Automatic Meter Readings
- 17.02 (Josef Noll)
 - ⇒ L5: Practical implementation of ontologies
- 24.02 (Josef Noll)
 - ⇒ L6: Multi-Metrics Method for measurable Security
- 03.03 (Gyorgy Kalman)
 - ⇒ L7: Communication in Smart Grid, Smart home and IoT
- 10.03 (Gyorgy Kalman)
 - ⇒ L8: Intrusion detection
- 17.03 (Gyorgy Kalman)
 - ⇒ L9: Paper analysis with 25 min presentation
- 24.03 (Gyorgy Kalman)
 - ⇒ L10: Paper analysis with 25 min presentation
- 31.03 (Gyorgy Kalman)
 - ⇒ L11: Cloud Basics
- 07.04 (Gyorgy Kalman)
 - ⇒ L12: Cloud security and IoT
- 21.04 (Josef Noll)
 - ⇒ L13:
- 28.04 (Josef Noll)
 - ⇒ L14:
- 05.05 (Gyorgy Kalman)
 - ⇒ L15: Selected recent topics from IoT security
- 12.05 (Gyorgy Kalman)
 - ⇒ L16: Wrap-up of the course



Department of Technology Systems



UiO : Institutt for teknologisystemer

Det matematisk-naturvitenskapelige fakultet



Long and nice history on communications and the birth of internet

Was home of the first ARPANET link to Europe made possible by internet-pioneer Pål Spilling, whom we lost a year ago.



Cooperation with the Kjeller-Institutes

First implementation of OLSR routing protocol



The threat dimension

- Ukraine blackout
- Surveillance camera DDoS
- AMS attack surface
- Exploiting cloud-elasticity
- Smart home – Always online
- Autonomous vehicles
- Ransomware
- Unauthorized resource usage (e.g. mining)

- Worth reading:

- → OWASP Internet of Things project
https://www.owasp.org/index.php/OWASP_Internet_of_Things_Project
- → Amazon Web Services IoT
<https://aws.amazon.com/iot/>



Problem 1: Energy Monitoring & Controlling

- UiO@Kjeller building
 - Smart campus management
 - Energy consumers
 - Meter data
 - Analyze saving possibilities
 - Potential for renewables or efficient use of spill heat/combined energy usage
 - Building automation and communication between buildings



Problem 2: Home automation

- Home energy costs are expected to rise
- Consumption is relatively non-flexible (schedule, convenience, insurance)
- Heterogenous installation with equipment from random vendors
- Smart plugs, meters, app-controlled lamps, heating elements
- Key in large consumers – largest possible benefit:
 - Electric car charging
 - Heat pumps (generally heating, hot water)
- Integration of renewables



Problem 2: Home automation

- Challenges to analyze:
 - Identify large consumers, integrate meter readings and introduce some kind of actuators or invest in «smart» device
 - Standards 10 years ago and 10 years from now: future proofing?
 - Control beyond «on-off»?
 - How to integrate e.g. solar panel production and energy storage
 - Air ventilation based on air quality measurement
 - Impact of spot energy pricing
 - Holistic view: extreme example: one could spare money with today's meter-less water pipes in Norway with using the continuous flow of tap water to cool the home instead of electricity. Of course this is not something to be done, measures should be evaluated as a whole system and also the whole footprint taken into consideration.



Problem 3: eHealth

- A service group made for the Norwegian dispersed settlement pattern
- Smart sensors, stationary and wearable integrated
- Fixed and mobile communication
- Different vendors, relatively random purchases
- Should be safe, reliable and secure



Problem 4: Building safety

- This time focus only on car charging
 - Lithium batteries are in practice inextinguishable once caught fire
 - Parking cellars, houses are specially at risk
- Sensors for monitoring the charge process:
 - Meters, temperature sensors, charge profile, prediction
 - Alarms, active measures (reduction, cutoff of electric power, CO2)
- Communication
 - Cellars are usually bad for wireless



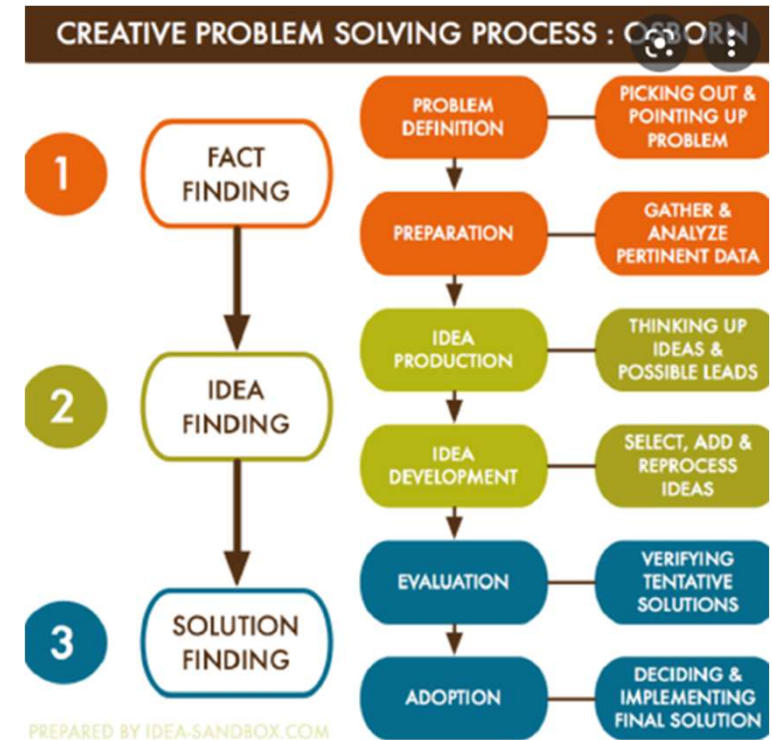
Problem 5: Farming

- Precise management of farming processes
- Monitoring and predicting needs and events
- Sensors for physical parameters
- Prediction based on historical results and models
- Control of machinery, predictive maintenance
- Safety and security
- Inventory, integrated management of equipment, consumables, chemicals etc.
- Wireless communication



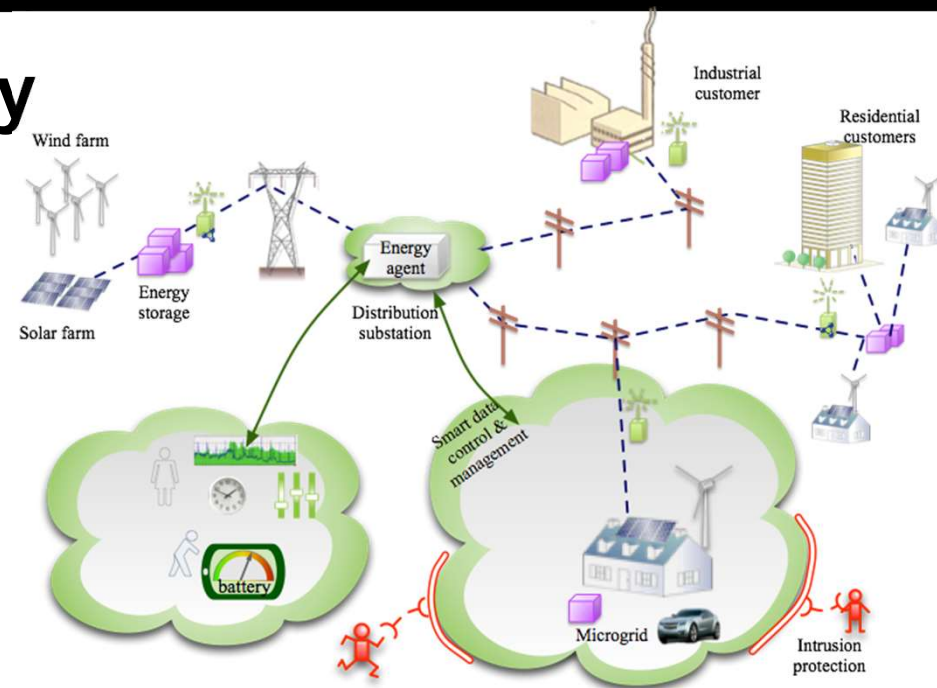
Path to solve problems

- Industrial approach (challenge, knowledge, opportunities, evaluation, solution)
- To be updated...



L1 - L3: Introduction to security

- This first part will provide the introduction into the Internet of Things (Lecture 1 - L2), with industrial examples
 - Smart Grid and automatic metering system (AMS)
 - Smart Homes with sensors
 - Wireless System upgrade of cars
- Lecture 3 will further address potential security threats, through the example of the smart electricity grid.



- Smart grid with prosumers
- Various control mechanisms
- Attack scenarios
- Critical infrastructure



Energy sector tops list of US industries under cyber attack, says Homeland Security report

12 March, 2015 at 6:38 PM Posted by: Jeremy Cowan

Washington, DC. March 12, 2015 — A report issued today by the US Department for Homeland Security says that in 2014 the Industrial Control Systems Cyber Emergency Response Team (ICS-CERT) responded to 245 incidents reported by asset owners and industry partners.

The energy sector, says *Jeremy Cowan*, led all others again in 2014 with 79 reported incidents, followed by manufacturing at 65 and worryingly healthcare at 15 reported incidents. ICS-CERT's continuing partnership with the Energy sector reportedly provides many opportunities to share collaborate on incident response efforts.



Power Grid Cyber Attacks Keep the Pentagon Up at Night

A detailed look at why computers running the U.S. electrical infrastructure are so vulnerable to digital threats

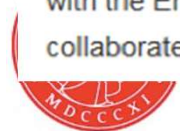
By Michael McElfresh and The Conversation | June 8, 2015

The following essay is reprinted with permission from The Conversation, an online publication covering the latest research.

It's very hard to overstate how important the US power grid is to American society and its economy. Every critical infrastructure, from communications to water, is built on it and every important business function from banking to milking cows is completely dependent on it.

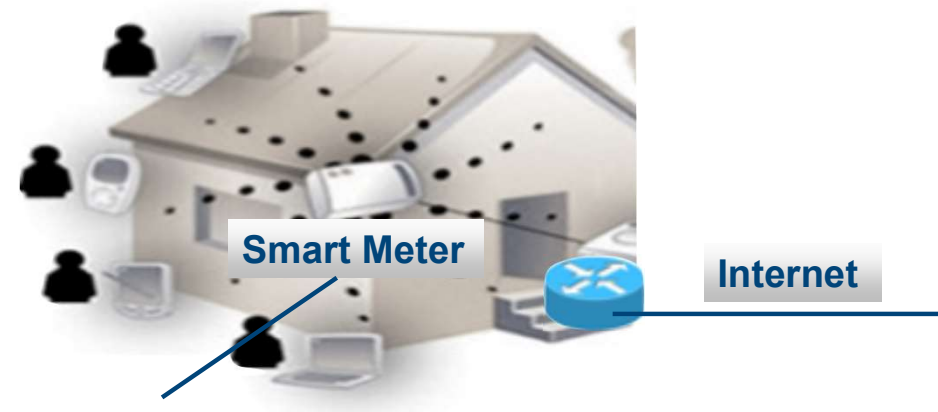


Scott Wylie/Flickr



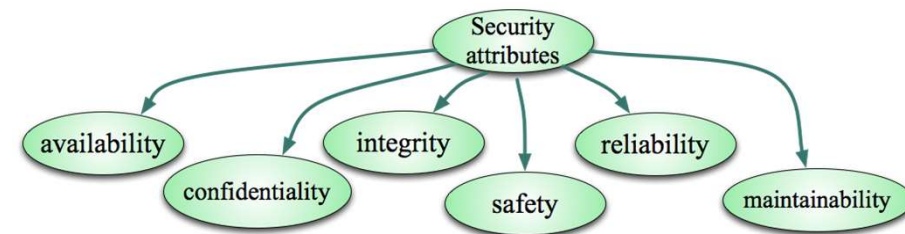
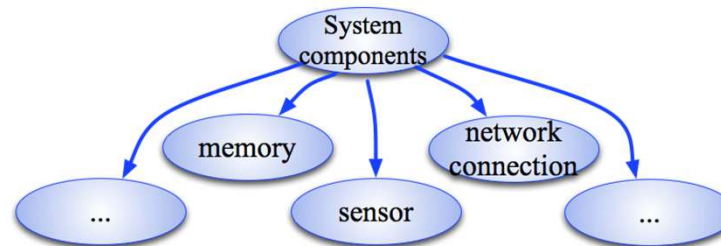
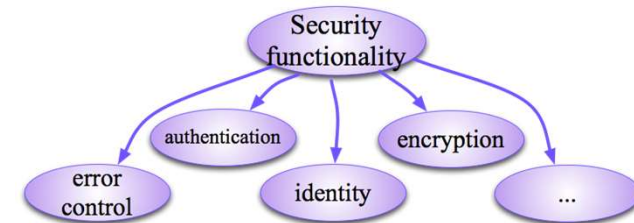
Security and Privacy challenges

- Example: automatic meter reading (AMR) and -system (AMS) - Insurance
- Mapping from functional requirements towards mapping into technology.
- Example: translation of privacy requirements - can somebody see from my meter reading if I'm at home
- Legislation questions – GDPR and others



Machine-readable descriptions

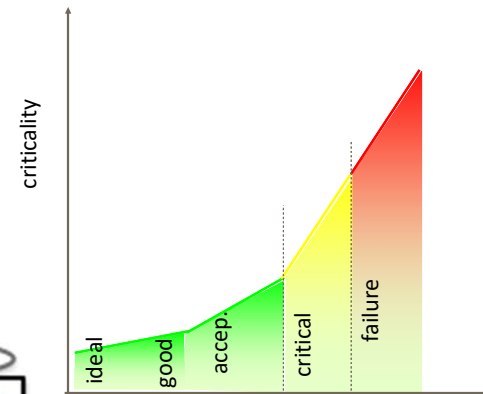
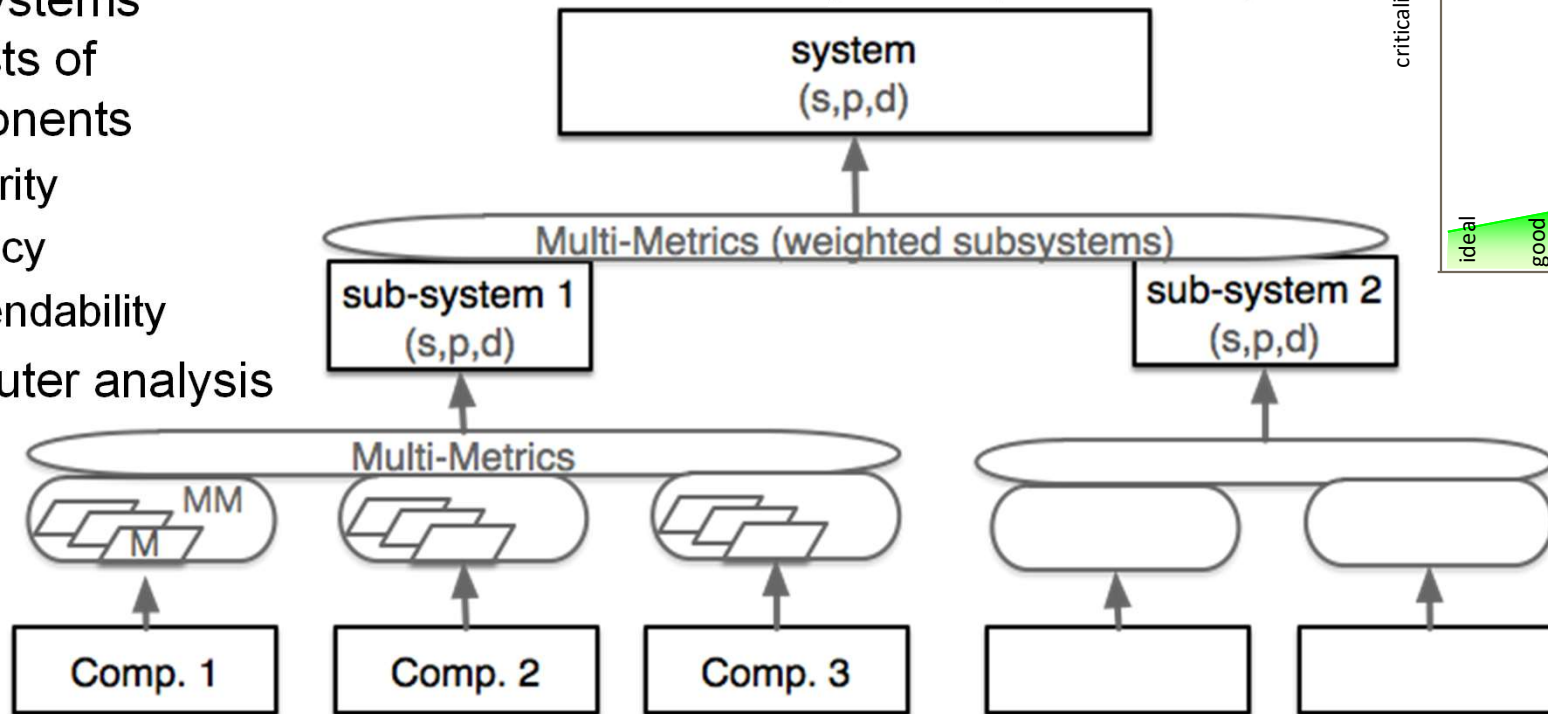
- Describe a system based on security attributes
- Introduction to the Semantic Web
 - Ontologies
- Rules & Reasoning
 - make decisions



Multi-Metrics method

- System consists of sub-systems
- consists of components
- security
- privacy
- dependability
- Computer analysis

SPD level	SPD vs SPD _{Goal}
(67,61,47)	(●, ●, ●)
(67,61,47)	(●, ●, ●)
(31,33,63)	(●, ●, ●)



Paper presentation

□ Methodology:

- Select (or search) for scientific papers
- Present the paper
- Discuss issues which you find interesting

□ Outcome

→ Personal:

- ▶ Learn to read and present scientific literature with own thoughts
- ▶ Be able to hold a presentation with time limits and active audience

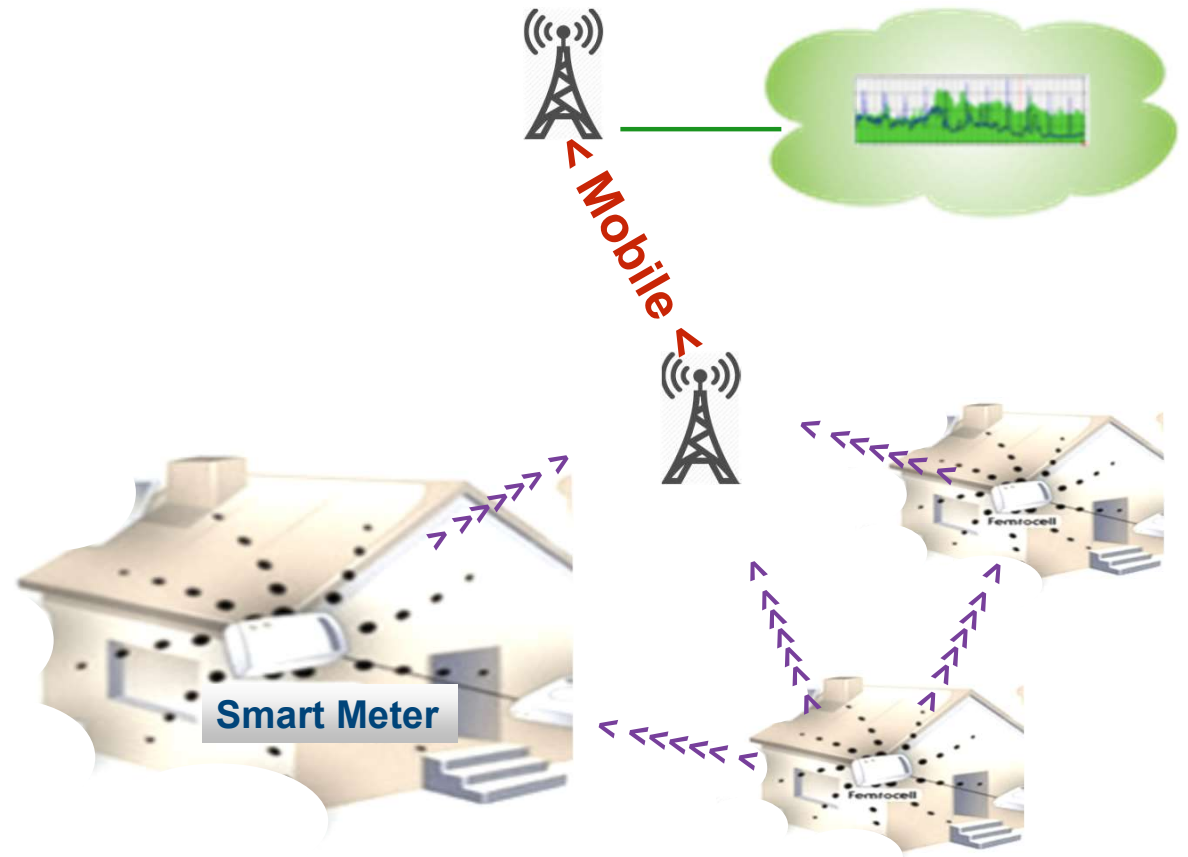
→ Course

- ▶ Get a fresh overview of the newest available research challenges and selected surveys of the field of the course
- ▶ Learn from how others are making their presentations
- ▶ Learn to ask questions



Real World Examples

- Real world examples
 - taken from industry, e.g. Smart Meter
 - billing,
 - Controlling
- Service implications on requirements
- Technology mapping
- Intrusion detection
- Communication in automation networks



[source: seminarsonly.com]



Cloud security

- An introduction to cloud and specifically, to AWS
- Cloud security, IoT and IoT support services from AWS



Recent news and Wrap-up

- Last lecture: Wrap-up, what you can expect on the exam, recent topics in IoT



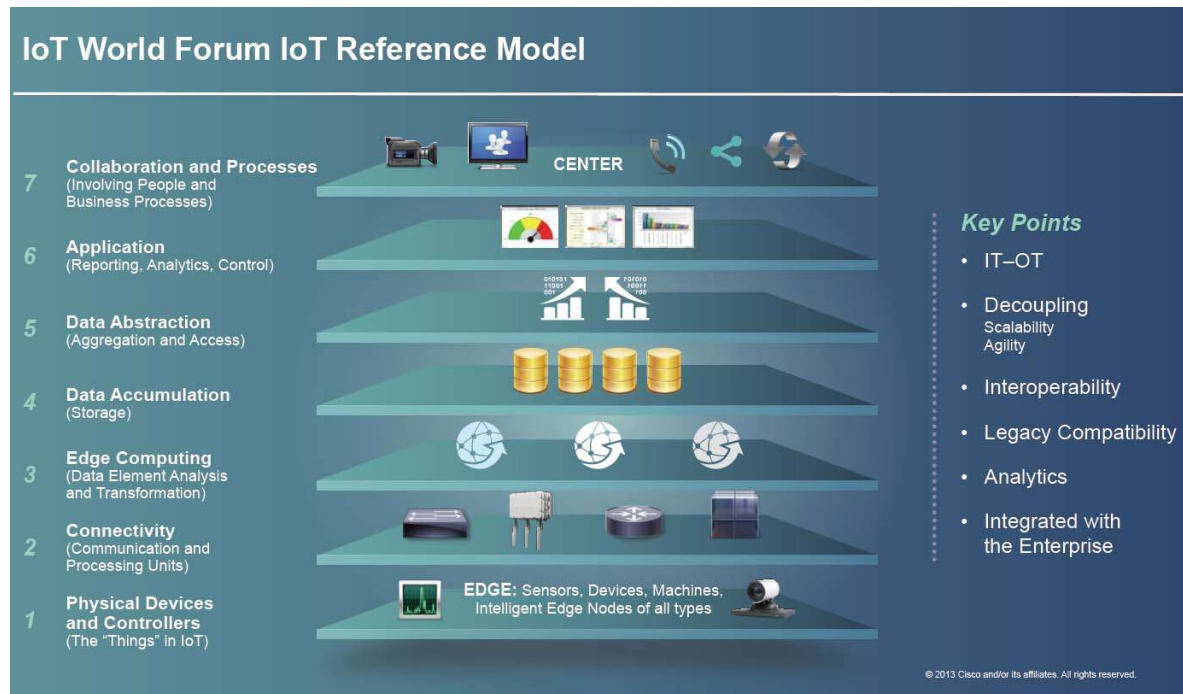
TEK5530 exam

- The final grade is based on
 - oral exam (100%).
- Paper presentation
 - Keeping the time limits
 - Clear presentation of the topic
 - Own evaluation of the work
- Oral exam
 - Questions to your paper presentation
 - Topics of the course



Internet of Things

- Heading toward a fully, often wirelessly connected world
- In a more focused way, in this course we focus on the electricity grid as example
- The substantial difference is, that IoT systems have a physical dimension
- Considered as the next industrial revolution
- Automation to a new connectivity level – the internet is coming to automation
- Main challenges: how to join the physical and the logical world, how to achieve interoperability in a heterogeneous and conservative industry?



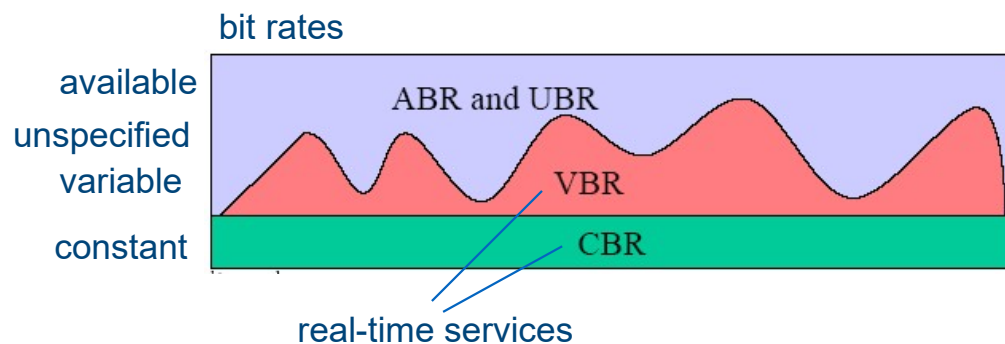
Internet as we know it

- Intelligence in the end nodes
- Best effort traffic
- Infrastructure = network equipment
- Operated by IT or telecom
- No direct physical dimension
- Mostly built to serve human-generated traffic

- QoS: best effort, adopted to the human consumer: 10s of ms of drop is not a problem, stable delay is accepted, majority of applications are bursty
- Reaction time in 0.5-1s range
- Stochastic → services do exploit this (like

Erlang-B formula for capacity estimation or lossy compression in nearly everything)

- High availability allows switchover in seconds



Automation as we know it

- Centralised intelligence
- Direct connection with the physical world
- Is made for information gathering and processing by machines
- Has a lag of approx. 15-20 years, but cost pressure is reducing it
- Still current questions: what happens if one has to share infrastructure with others, how to operate a link with long step-out distance, use of Java
- Economic press leads to adoption of internet-based services which *require* a paradigm change
- The electric grid is the largest interconnected national infrastructure service



Mine (Boliden)



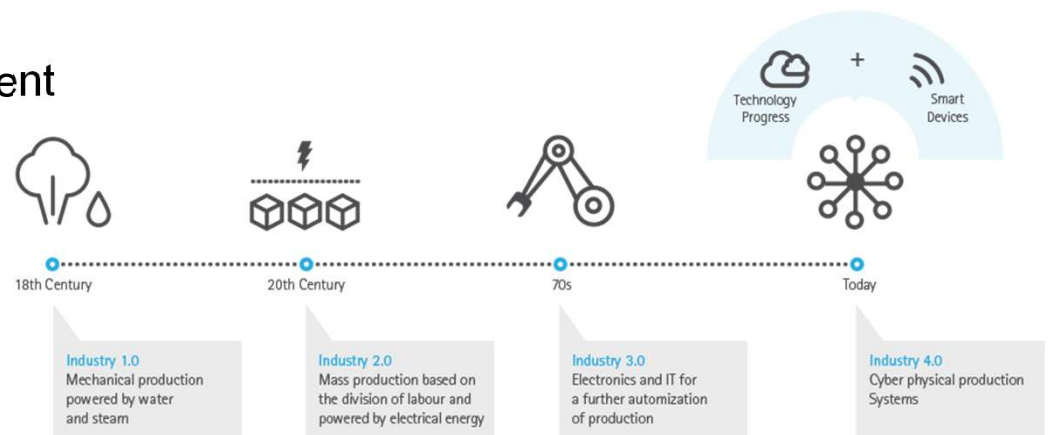
ABB robots



<http://www07.abb.com/images/libraries/provider104/Extended-Automation/control-room-consolidation-by-abb.png?sfvrsn=1>

Merging these two in the Smart Grid

- Uses communication and complex services to enhance resiliency and to allow better utilisation
- Integration of renewables requires the integration of a large number of production nodes
- Internet is the infrastructure – sensor, actuator, controller not on the same physical network any more
- "dissolves" the automation system in the internet
- Automation processes run over an unknown communication infrastructure
- Network communication gets physical impact
- Automation meets real internet-type deployment
- The real value of IoT: data.
Cloud and big data will enable new services
- Challenges of security:
 - ☞ Configuration management
 - ☞ Standardization or lack of
 - ☞ Long value chains



<http://prd.accenture.com/microsites/digital-industry/images/digital/industrial-infographic-large.png>



Interesting challenges

- **Architecture:** physical impact, end-to-end resource reservation, discovery, safety, security and privacy
- **Governance,** interoperability, standardisation
- **Managing risk** in a system with impact on both logical and physical level
- Provide QoS over a best effort infrastructure – with a price pressure
- **Data Aggregation:** here lies the added value, enables novel services and higher efficiency
- **Distribution of intelligence:** make the automation system more internet-like: intelligence in the end-nodes. Support it with the recent it trends of cloud and big data. Challenge for traditional automation mindset.
- Open architectural model
- Security concerns are a critical barrier for wide scale adoption of IoT
- Cloud and IoT
- See when IT has arrived to the phone industry. Or when IT has arrived into telco backhaul. IT is arriving to automation.



IoT services

- Enabled by wireless communication
- Cheap mobile data traffic
- Wide scale data gathering
- Monitoring of massive systems
- Real-time insight to processes
- Performance measurement and optimization
- Proactive and predictive methods
- To serve the automation goals, the services provided must be: scalable, distributed, have a real reference to the physical world (e.g. time), must ensure security and privacy of the users
- Just using existing security solutions is not necessarily leading to secure IoT deployments
- Composed by IT, operations and the IoT enabled objects
- * Following slides are from the presentation of Mikhail Kader, DSE, Cisco, presented on the ITU Workshop on “ICT Security Standardization for Developing Countries”



Connected Rail Operations *

PASSENGER SECURITY

- In-station and onboard safety
- Visibility into key events

ROUTE OPTIMIZATION

- Enhanced Customer Service
- Increased efficiency
- Collision avoidance
- Fuel savings

CRITICAL SENSING

- Transform “data” to “actionable intelligence”
- Proactive maintenance
- Accident avoidance



Cost savings, improved safety, superior service



Secured COnnected Trustable Things (SCOTTproject.eu)

"Building Trust in the Internet of Things"

SECURITY



SCOTT DEMONSTRATOR BOOKLET
SCOTT USE CASE BOOKLET

What is SCOTT?

SCOTT RESULTS

Publications
YouTube

USABILITY



PRIVACY

TRUSTABILITY



SAFETY



Smart City *

CONNECTED TRAFFIC SIGNALS

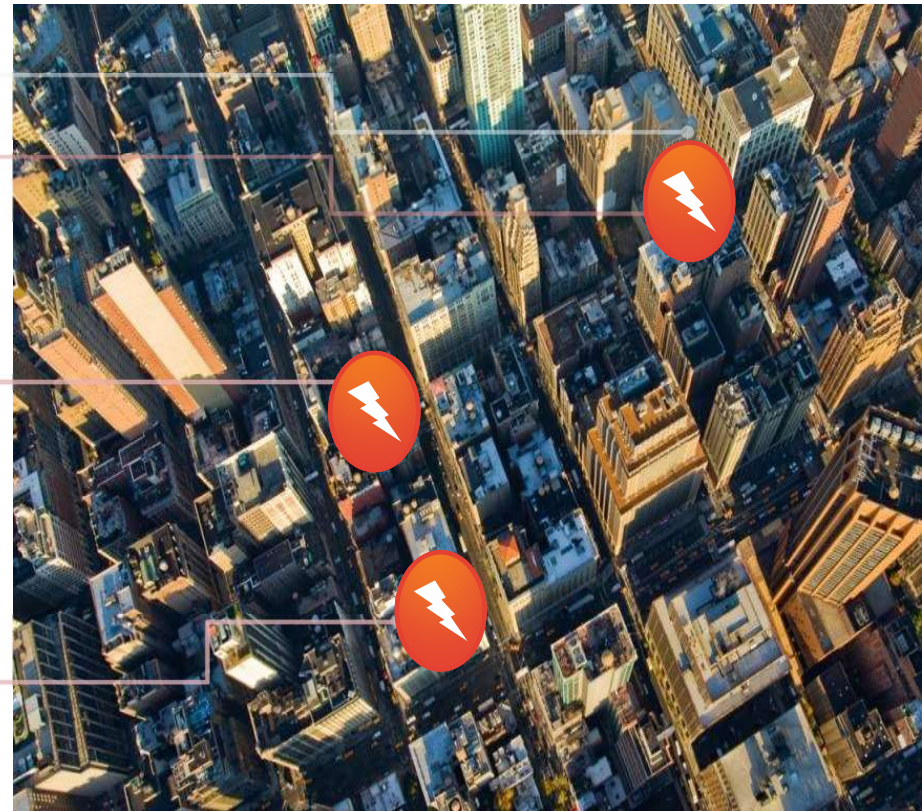
- Reduced congestion
- Improved emergency services response times
- Lower fuel usage

PARKING AND LIGHTING

- Increased efficiency
- Power and cost savings
- New revenue opportunities

CITY SERVICES

- Efficient service delivery
- Increased revenues
- Enhanced environmental monitoring capabilities



The Connected Car *

WIRELESS ROUTER

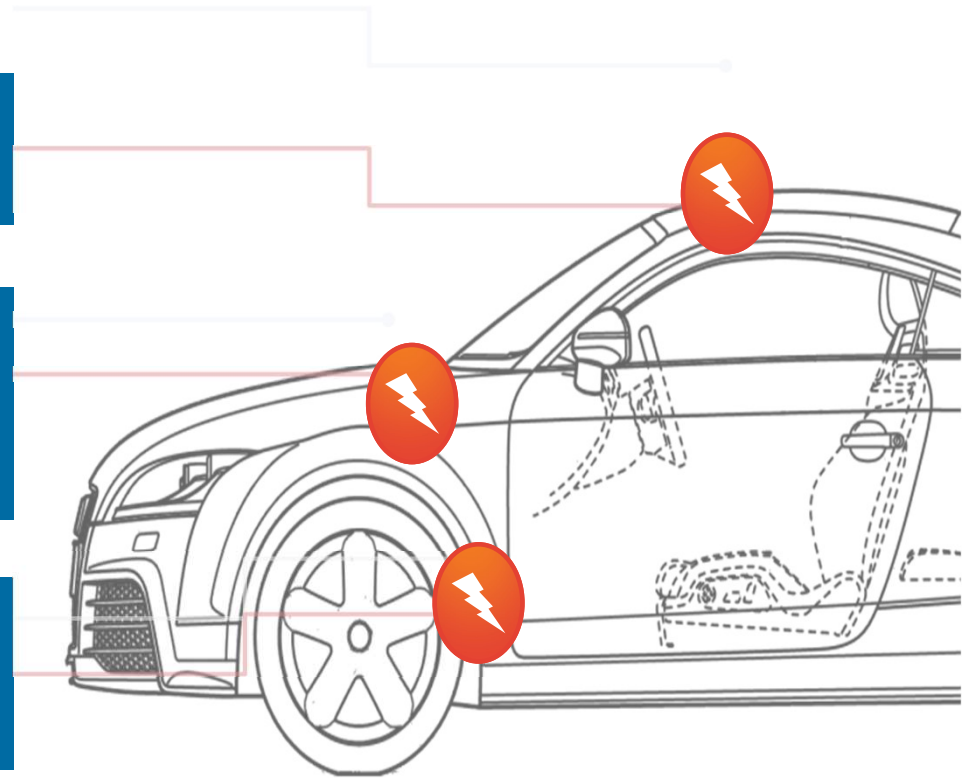
- Online entertainment
- Mapping, dynamic re-routing, safety and security

CONNECTED SENSORS

- Transform “data” to “actionable intelligence”
- Enable proactive maintenance
- Collision avoidance
- Fuel efficiency

URBAN CONNECTIVITY

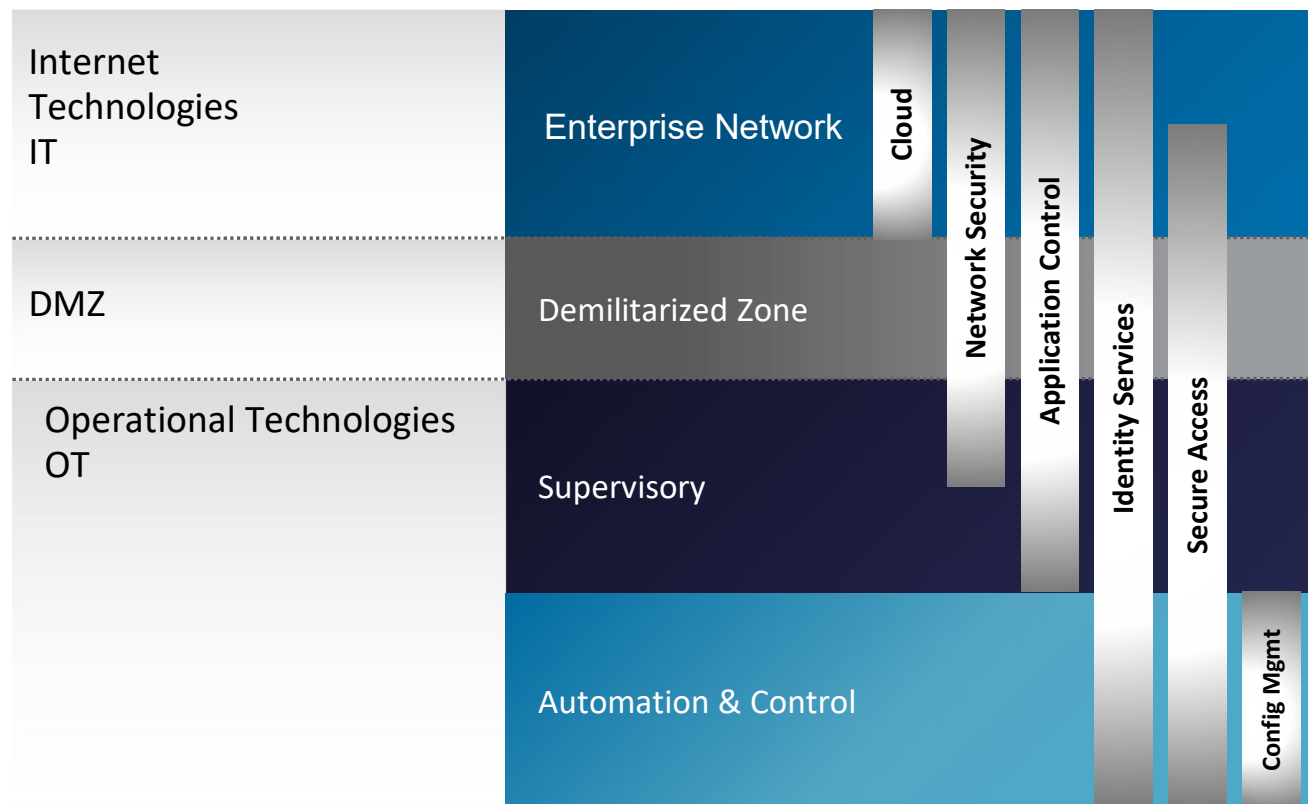
- Reduced congestion
- Increased efficiency
- Safety (hazard avoidance)



IoT Expands Security Needs *



IT/OT Converged Security Model *



IT and OT are Inherently Different *

- **IT**
 - Connectivity: “Any-to-Any”
 - Network Posture: Confidentiality, Integrity, Availability (CIA)
 - Security Solutions: Cybersecurity; Data Protection
 - Response to Attacks: Quarantine/Shutdown to Mitigate
- **OT**
 - Connectivity: Hierarchical
 - Network Posture: Availability, Integrity, Confidentiality (AIC)
 - Security Solutions: Physical Access Control; Safety
 - Response to Attacks: Non-stop Operations/Mission Critical – Never Stop, Even if Breached



What Can Lead to Breach in IoT Networks?

- What can't?
 - Billions of connected devices
 - Secure and insecure locations
 - Security may or may not be built in
 - Life cycle mismatch between IT and automation devices
 - Installed base
 - Clash between IT and OT, IT has to accept the traffic

- Any node on your network can potentially provide access to the core



L1 Conclusions

- Overview over lectures
- Explanation of portfolio and exam
- Introduction to topic blocks
- Discussion



[Source of starred slides: Monique Morrow, Cisco]